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# The Floodlighting of Historical Buildings and "Sound and Light" Spectacles in France

By JEAN J. CHAPPAT *(Member)*

Perhaps I may be allowed, in commencing this talk, to thank you for inviting me to come and speak to you on the illumination of historical buildings in France.

I trust I shall not be deemed guilty of exaggerated national pride in saying that it is in my country that this form of lighting has made most progress in recent years, both on the technical and on the artistic plane. In France are to be found the largest number of floodlit buildings, and the "Sound and Light" spectacles, created for the first time at the Chateau de Chambord in 1952, are developing on a larger scale every year on fresh sites.

Before proceeding with my talk I should like to pay a tribute to my friend, the late R. O. Ackerley, who, as you will recall, read a paper on "Floodlighting" at the Summer Meeting of your Society at Buxton in May, 1950[1]. I have re-read the text which he wrote at that time. It still constitutes a complete epitome of the technique of floodlighting, and the principles he enunciated are still those that our technicians apply every day.

## History of Illuminations in France

The origin of the floodlighting of historical buildings in France probably dates back to the end of the First World War when on November 11, 1918, Strasbourg Cathedral was floodlit by military searchlights. I have always retained the memory of that perforated spire, a real piece of stone lace standing out in the Alsatian night, and I then understood that Light was truly the symbol of life and joy, which had been found once more in peace.

Ten years elapsed before this attempt was given its first permanent application. It was indeed for the anniversary of the Armistice that, on November 11, 1928, the Arc de Triomphe de l'Etoile in Paris was floodlit for the first time. Let us recall here the name of the artist cum technician to whom we owe this: Jacopozzi, an Italian born at Florence who had come to France in about 1900; he had already made himself known to Parisians through the boldness of his lighting ideas. Was it not he, indeed, who in 1925 affixed to the Eiffel Tower, right up to its 300 metres tip, an advertisement for a make of car, which took the form of thousands of incandescent lamps whose patterns were constantly changing.

It was due to Jacopozzi that in 1928 Paris had its chief buildings floodlit: the Place de la Concorde, the Madeleine, the Opera House, Notre Dame, Sacré-Coeur, etc.

If we except some temporary floodlighting in certain provincial towns, Paris was for a long time alone in regularly floodlighting its principal buildings. It was for this reason that in 1937, on the occasion of the international exhibition called the "Exhibition of Arts and Technology," it was decided to send through the country five convoys, provided with electric generating plant and equipment, making it possible to floodlight the more outstanding stone structures in every town or region.

This "Lighting Tour de France" occupied six months and about 500 buildings or sites emerged for a few evenings out of the veil of the night. It was a wonderful experience for the inhabitants and the memory of that luminous caravan has remained present in the minds of many local authorities, who now avail themselves of floodlighting to contribute to the beautifying of their cities by night.

Then came the Second World War, followed by a period when the shortage

The author is with the Compagnie des Lampes, Paris. The lecture was presented at meetings of the Society held in Peebles on May 7, 1955, and in London on May 10, 1955.

of electricity permitted its use only for strictly limited purposes. Nevertheless, when the C.I.E. held its eleventh meeting in Paris in June, 1948, we were able to obtain permission to operate the installations once more, for the first time since the war. I recall the first evening when the Arc de Triomphe, the monuments on the Place de la Concorde, Notre Dame Cathedral, etc., finally emerged from a 10-year blackout; all the Parisians were in the streets and the coaches we had hired to show the illuminations to members of the C.I.E. had extreme difficulty in making their way through the dense crowds which were celebrating the floodlighting of the ancient stones. Once again, Light was a source of joy and marked the return to life of a city whose soul had been deeply scarred by the war, even if its body was intact, for its architectural wealth has miraculously been spared. In order to interest the municipal authorities in the floodlighting of buildings in the years that followed, we developed a system of renting material, projectors and lamps. Religious or secular festivals and sporting events provided opportunities for showing spectacular effects and the tourist interest in floodlighting, and orders for permanent installations were received at a rate that gathered momentum from year to year.

In 1951 the Prefect of Tours took the initiative and arranged for the floodlighting, not only of the superb cathedral in that city, but also of some of the celebrated chateaux which surround it : Amboise, Langeais, Villandry, Luynes, Azay-le-Rideau, etc. Night trips by coach were organised to enable tourists, whose interest had been attracted by well-conducted publicity, to visit every year those jewels of the Loire valley.

The success of this undertaking was immediate and exceeded the very hopes of the organisers. Two figures will suffice to give you some idea of the success achieved : the various taxes and fees accruing from the money spent by tourists in the departement in question rose from 200 million francs in 1950 to 320 million francs in 1951.

Fired with enthusiasm by this success, the Prefect of Blois decided to do better still in his neighbouring departement of Touraine. He accepted a new and bold idea placed before him by the keeper of the Castle of Chambord, Pierre Robert-Houdin. The latter suggested combining sound effects with the floodlighting of that castle and the creation of a real scenario where (I quote the report) " commentaries and recorded music harmonise with the floodlighting of the building."

On May 30, 1952, the first " Sound and Light " spectacle was born and those who, like myself, had an opportunity of taking part in that fairylike reconstruction of life at the Chateau de Chambord, took away with them the impression that a new mode of artistic expression had just been created. The reception by the public was just as enthusiastic there and it was once more a financial success : the 15 million francs spent on the enterprise were, in fact, recovered in the first year through the influx of 150,000 spectators.

The following year, 1953, the spectacle of the Chateau of Versailles was organised, while other historic buildings, Chenonceaux, Villandry, etc., also accompanied their lighting with sound.

The installations grew in number very rapidly and more than 15 " Sound and Light " spectacles are now being shown every summer evening. Among the latest to be installed may be mentioned the stronghold of Vincennes near Paris, the palace of the Popes at Avignon, the Basilica of Lisieux, the delightful little castles of the Cher, and quite recently the chateau of Chantilly.

It would take too long to enumerate all the static floodlighting that has developed on parallel lines throughout the country. We would nevertheless recall the demonstrations made by the Association Française des Eclairagistes in the cities of Toulouse in 1952, Dijon in 1953 and Monaco in 1954. These were temporary installations during the period of the annual congress of the A.F.E., but their exceptional extent totally transformed the appearance of the cities. At Monaco, in particular, the remarkable site which forms the celebrated " Rock " was floodlit with changing colours,

and the Principality retained throughout the year the installations which drew a large number of visitors.

I feel that this historical summary is useful in bringing to your notice the continued effort made by the manufacturers in France, an effort whose fruit they are now gleaning. There are at present in France few towns, whether large or medium-sized, which are not conspicuous at nightfall through the floodlighting of the towers of a cathedral or the keep of a castle for the benefit of the tourist who is lured by the charm of our countryside and the splendour of our buildings.

## Technique of the "Sound and Light" Spectacles

### The Material

It is not my intention to refer here to the characteristics of the various methods of floodlighting or the general methods of their application. I am speaking to illuminating engineers who are perfectly conversant with this problem which has, I repeat, been admirably handled by R. O. Ackerley in the paper to which I have alluded[1].

I will, nevertheless, give you some particulars of the improvements we have made to this technique as the number and scope of the installations developed.

For a long time the only projectors that could be used were of the classic type with silvered glass or metal reflectors, fitted with lamps of the standard or floodlighting types, yet whose power did not exceed 1,000 watts.

These projectors produce a conical beam having a circular base, the spread varying according to the model. This beam spread is, I may remind you, defined as the angle subtended at the source within which the illumination on a plane normal to the axis of the beam will not have a greater diversity than 10 : 1[1].

In such projectors, part of the beam of light situated outside this angle cannot be used; you call it "spilled light" and the edges of the beam are for this reason shaded off, which in many cases causes unpleasant half-shades of light on certain parts of the building.

The relatively low power of projectors of this type (500 or 1,000 watts) and the fact that part of the beam cannot be used create two drawbacks: (1) A comparatively large number of projectors is needed to light even a small area and (2) the projectors must be placed at a short distance from the buildings (10 to 50 metres at most).

There is, however, a type of projector based on quite a different principle and which obviates these defects. It is to this projector that we owe the excellent results of which I have spoken; it is called the Infranor.

This apparatus uses a special projector lamp of 3,000 watts, silvered inside on a spherical bulb. It is placed in the apparatus in such a way that the whole of its light flux is reflected by a mirror placed at the bottom of the metal body. This mirror is made up of anodised aluminium plates, the arrangement and curvature of which make it possible to obtain different shapes of beam, parabolic or elliptical. The beam has a rectangular base and its edges are sharp, for no direct flux from the lamp leaves the apparatus.

The beam spread, designated by the vertical angle and the horizontal angle, can, according to the mirror used, be 60/20 deg.—60/5 deg.—40/20 deg.—40/5 deg.—25/20 deg.—25/5 deg. Regulating the position of the lamp moreover enables the beam spread to be varied. For instance, for a 40/5 deg. optical system, the spread may be as much as 40/12 deg. In addition, by turning the mirror through 90 degrees, it is possible to obtain a high beam, e.g., 20/60 deg.—5/60 deg., etc.

The efficiency of the Infranor projector is such that a single 3,000-watt projector gives the same result as 10 ordinary 1,000-watt projectors. This reduction in the number and total output used goes hand in hand with the advantage of being able

*Fig. 1. (above) Chateau de Versailles.*

*Fig. 2. (left) Showing loudspeakers on building.*

to group the apparatus at one point or at a few points only, which makes it possible to obtain directional effects comparable with those produced by the sun.

The positional distance is likewise increased and distances of 100 to 200 metres are common. In the floodlighting of Monaco referred to on page 244, the projectors were set up 300 metres from the Rock.

In this way the directional effect is improved, the inclination of the beam becoming almost horizontal, which cannot be obtained with apparatus placed at a short distance from the monument.

For all these reasons, Infranor apparatus is now used in most installations to obtain the general floodlighting of a monument or a site.

The other types of projector are used for accent lighting, for toning down shadows, or perhaps for lighting a limited subject outside the main building, such as a statue.

During rehearsals a choice of projectors and their positions is made, the object being to produce a " natural " effect, similar to the daylight appearance of the building, whilst giving the building suitable relief.

Finally, in the course of these spectacles, sometimes the light is concentrated on a

particular detail (the lantern of the Chateau de Chambord, for instance), sometimes the field of vision is widened by lighting the foliage of trees, fountains or even the statues which surround the building. Thus the scene shrinks or widens as the action proceeds, the absence of light playing the part of the proscenium curtain while the scene is being changed.

I will not stress the need for concealing the apparatus, at least during the day, from the sight of visitors. Various traditional methods are employed, in particular the concrete trench, out of which they are raised mechanically. This method is used, for instance, round the Arc de Triomphe and in the Versailles gardens. Those who have been in Paris are acquainted with the second-hand booksellers' boxes placed on the parapets of the Seine quays. Some of them have been transformed to mask the Infranor projectors which light the side and apse of Notre Dame.

**Colour**

Ever since attempts have been made to bring life to buildings or gardens by artificial light, experiments have been made at colouring the light so as to increase the range of possible effects.

The first idea was to use, as on the stage, screens of coloured glass or gelatine. However, besides the fact that these absorb a large part of the light flux, the shades obtained are generally too pure to create an artistic effect unless, as we shall see later on, there are a large number of sources of light permitting of varied and pleasant blends of colour, as is done on the stage of a theatre. Use has also been made of sources of coloured light, the blue-green of mercury vapour and the yellow of sodium. With these lamps, however, clashes of shade are sometimes considerable and a good deal of skill is needed to obtain, for instance, a harmonious straw yellow by mixing sodium and filament lamps.

In the French illuminations, and especially in the "Sound and Light" spectacles,

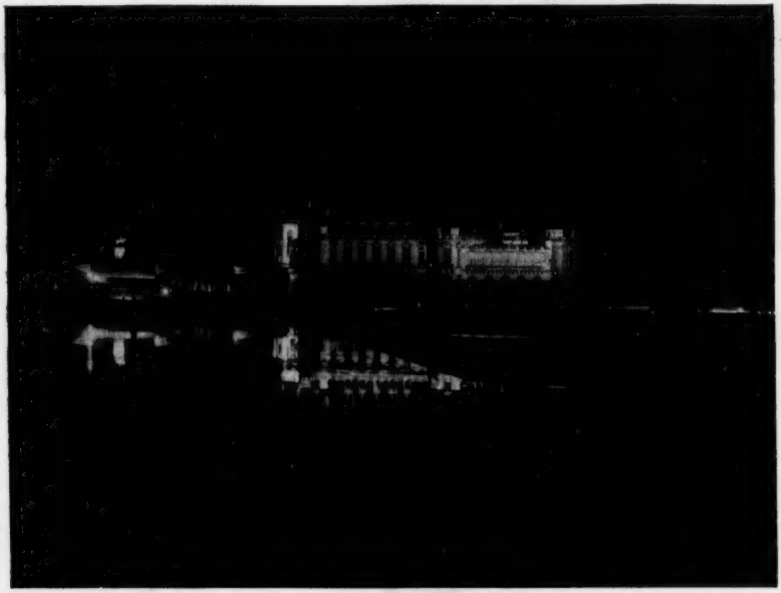

*Fig. 3. Chateau de Chantilly.*

delicate shades have to be obtained so that neither their juxtaposition nor their sequence is likely to create in the spectator an impression of suddenness, which may break the spell it is hoped to cast on him.

Once more it is the Infranor projector that has helped these attempts. Owing to the fact that this apparatus only projects light reflected by its mirror, it is possible by colouring the latter to alter the tones of the light flux; by anodising the aluminium plates, pleasant shades of pastel blue, gold, red, etc., are obtained.

**Controlling Light and Colour Effects**

The control of the lighting of the different surfaces of a building, whether it be a question of regulating the intensity of the light, or of determining the colour effects,

*Fig. 4. Booksellers' boxes on the Seine quay concealing projectors.*

*Fig. 5. The chromoselector.*

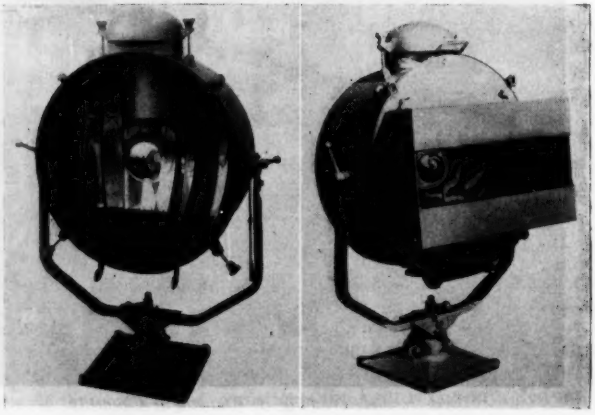

*Fig. 6. Infranor projector without screens.*

*Fig. 7 (right). Infranor projector with screens.*

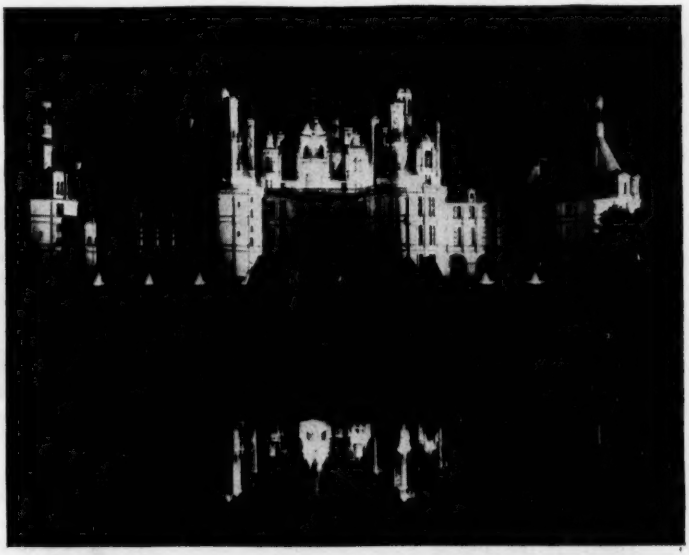

*Fig. 8. Chateau de Chambord.*

is carried out as in the theatre by means of resistances, auto-transformers or thyratrons, the whole of which constitutes an "organ console."

The extent of the scene to be floodlit, however, raises some special problems which have had to be solved. At Versailles, for instance, the spectacle takes place, on the one hand on the park façade of the palace, which is 400 metres long, and on the other in the gardens over a length of almost a kilometre. The operation of 1,000 projectors requires a total of about 300 kilowatts distributed in 96 circuits and the length of the cables installed exceeds 60 kilometres.

It is not my intention to describe in detail this grandiose installation which some stage lighting and television technicians from Britain studied on the spot last year. Some very complete accounts of the sound and light installations have been published, in particular by L. Gaymard[2, 3], J. Reyval[4] and Georges Leblanc[5]. I would, however, like to draw your attention to an apparatus for marking and controlling the colours, which is termed the "chromoselector."

It is indeed necessary to be able to regulate, in the course of the performance, the effects of the intensity and colour of the different points where the result can best be judged. It must also be possible to repeat them in an absolutely identical fashion in the course of each performance from the control hut, which is generally placed in the basement of the palace.

The chromoselector, whose invention is due to the work of Georges Leblanc, the stage lighting specialist, is an apparatus which makes it possible to explore the whole gamut of shades obtainable by means of three or four circuits controlling coloured sources. In the theatre, for instance, mixtures of blue, green, yellow and red lights can be remote controlled by a single operation, to provide all the desired hues of the spectrum, ranging from pure tints to pastel shades, faint tints and even pure white.

This is a great improvement on the apparatus of the type hitherto in use. It consists of a desk carrying a chart on which is reproduced the C.I.E. colour triangle. In

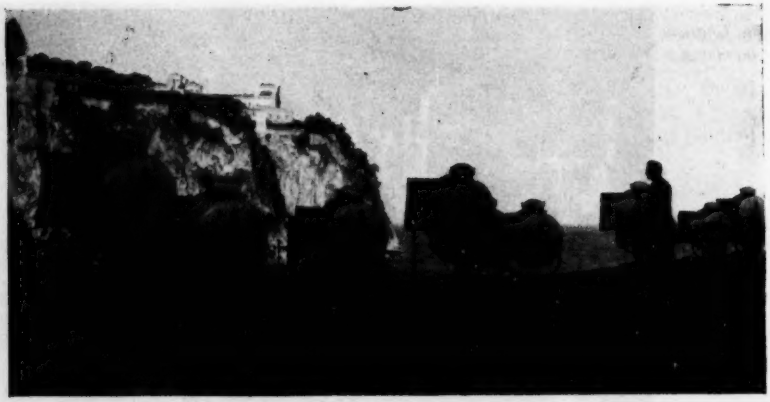

*Fig. 9. Infranor projectors in position to floodlight the Rock of Monaco.*

the desk itself are two mobile systems controlled by a knob on the desk which, through relays and potentiometers, control the levers of the organ console.

Thanks to this apparatus it is possible not only to get the desired colour but also to maintain it; in certain cases the lighting intensity can be regulated at will.

The chromoselector is a lightweight apparatus which can be taken for rehearsals to the place where it is most convenient to judge the effects. Thus, for obtaining coloured illumination of the rock of Monaco, 16 3-kw. Infranor projectors, provided with tinted reflectors, were regulated by auto-transformers, themselves remotely controlled by a chromoselector. The latter was connected to them by five lines of the Monaco telephone system(5).

**The Sound Effects**

The idea of combining sound with light is due, I would remind you, to Robert-Houdin, the keeper of the Chateau de Chambord. The first spectacle was performed on that building in 1952. Here again a new technique has been used which involves great improvements to open-air sound transmissions, such as we are accustomed to hear at sporting events or fairs.

The loud-speakers are of a special type, designed by Leon and termed "Elipson conch." This apparatus has a marked directional effect and makes it possible to suppress, by a suitable device, outside sounds such as interference echoes on the surrounding foliage while giving the spectator the distinct impression that the sound comes from differently located sources.

We are, moreover, indebted to the research of Jose Bernhart and Jean W. Garret for the perfection of a so-called directional "stereophony" process, which enables sound perspective to be obtained, as well as continuous movements of sound in space.

I cannot do better than quote for you the principle of this sound process, as explained by Milon in his paper to the A.F.E. at Monaco(6):—"Let us consider two sources, one to the left and the other to the right. If we apply a given intensity at the left-hand source, the impression is gained that the sound is coming from the left, and vice versa. Moreover, if this intensity be applied to both sources, there is obtained subjectively a single source-picture whose position in space depends on the distribution of the intensity between the left- and the right-hand sources. If the same intensity is applied to these two sources, the source-picture is centred between them.

It will thus be seen how easy it is to obtain the effect of movement from left to right, by altering progressively the intensity of the sources from left to right."

Many difficulties have had to be overcome in the course of preparing for the spectacles. For example, arrangements have had to be made to compensate for acoustic distortion due to gusts of wind which at times seemed to be making the instrumentalists play out of tune. When the weather was still, on the other hand, mist occasionally had the effect of weakening the sound, especially the top notes, more than 25 decibels from the initial level.

The adjustment of the sound reproduction is a delicate and extremely complex operation. At Versailles, for instance, it was necessary to record at the same time an orchestra of 80 musicians and 50 singers, the texts spoken by a number of actors, whilst adding the sound effects in which over 200 took part.

## Producing "Sound and Light" Spectacles

Thus the creation of a "Sound and Light" spectacle calls for lengthy preparation and perfect co-ordination of the artistic and technical elements. "It seems to me desirable," said Martin Demezil(7) "for such a spectacle to be the work of a small and solidly welded team, if possible working under one man."

It should be clearly understood that stage and film procedure is not called for. There is indeed a stage on which the light and the sound are the actors. The scenery is, however, fixed throughout the spectacle and only voices suggest the presence of

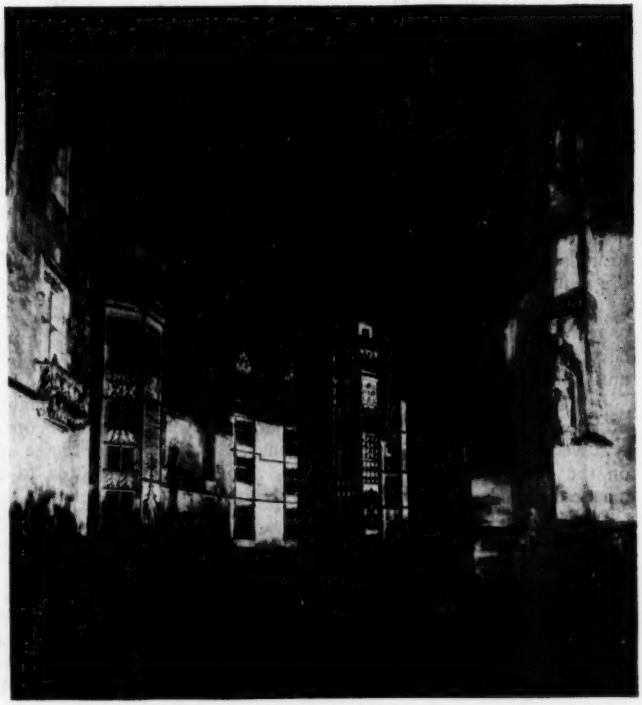

*Fig. 10. Chateau de Meillant.*

human actors. Similarly, only changes in light and colour and movements of sound suggest the action which is taking place, and here an appeal is made to the spectator's imagination. The first stage consists of selecting the theme corresponding to the character of the building, its past, and its glory, while at the same time avoiding the history lesson style; indeed, as stated by Martin Demezil, "historical truth" should be changed into "poetic truth." I am bound to admit that this degree of perfection is not always attained and that certain spectacles leave something to be desired on this point. We are, of course, dealing with quite a new form of artistic expression and it is inevitable that authors should proceed tentatively before finding the right poetic style. The themes selected for each building are reflected in the title given to the pageant:—

at Chambord we have "Les très riches Heures de Chambord."
at Chenonceaux: "Au Temps des Dames de Chenonceaux."
at Villandry, famous for its gardens: "Le jardin Enchanté."
at Chateau d'Ainey, in the Cher: "Le Sourire des Siecles."
at Versailles: "A Toute les Gloires de la France."

When the theme has been decided on, while the authors of the script and the music are preparing respectively the text and the score, the lighting technicians are asked to get busy. Of course, every time there is a speed record to be broken, for, if the decision has been a long time pending, it is essential for all to be ready at the beginning of the tourist season. Thus the enormous undertaking of Versailles was carried out in only three months, whereas normally at least six months would have had to be allowed, as pointed out by Gaymard[3].

The lighting tests therefore start at once, if necessary by supplying the projectors from generating units, so as to determine what effects can be obtained from which a choice can be made when the text is known. Each effect is numbered and all the necessary information, e.g. type of projector, number, output, colour, position, etc., are noted and often a photograph completes the file.

By proceeding thus, those responsible for the pageant can, as soon as they are in possession of the text, decide on the lighting effects they consider suitable, which enables the technicians to decide on the initial distribution of sites and projectors and to calculate the total wattage to be provided for. True, this is still only a preliminary outline of what will eventually be done, and it is as well for the forecasts and estimates to make provision for a large number of alterations, additions and reinforcements that are required for each new test; this goes on up to the date of the general rehearsal.

To give you an idea of what the mere study of the lighting can represent for a pageant like that at Versailles, I will mention that "more than a hundred different effects were tried out in the course of a hundred rehearsals, some of which lasted until dawn"[2].

We must add that these take place in the open air by night, and that distances of several hundred metres separate the different groups of operators. We are far removed from the working conditions that exist on the stage of a theatre or even on the vast set of a cinema studio. Since it is impossible to give orders even by megaphone, telephone communications have to be used between the different positions. Other conditions to be contended with are the cold at night, weariness and even sleep, and there must be no giving way to the nervous irritation which results therefrom and sometimes attacks even the calmest.

In the Versailles pageant there is one lighting effect that is particularly striking for the beholders: this is when the suggestion of a banquet causes the celebrated Galerie des Glaces to be lit up from inside. The impression had to be given that the lighting was due to the flickering glimmer of candles. This was done by placing above the cornices series of tinfoil sheets moved by small fans, and on to which the

projectors cast coloured light. I mention this example to show the anxiety for new effects on the part of lighting technicians.

In certain cases, at Chambord for instance, Bengal lights are used to accentuate certain scenes. Such research, however, is most delicate. The danger of falling into the style of the travelling show must be avoided at all cost, and this is why the production should only be entrusted to men whose artistic taste goes hand in hand with a fairly accurate memory for history, if the anachronisms are to be avoided which we, alas, so often see in the cinema.

From producer to electricians, with the intermediate stages of author, musician, light and sound technicians, all those who contribute to the making of a "Sound and Light" spectacle are inspired by the same faith in the work they are combining to create, which becomes more and more perfect every day and which resurrects before their eyes the shades of those who have animated these historic places by their presence, where the light now restores the lost brilliance.

## Future of "Sound and Light" Spectacles

Some people have expressed the fear that the craze for sound and light pageants is only a passing one and that the public's enthusiasm will soon wane. There is no doubt that the attraction of novelty plays a large part in the minds of those who want to have seen Versailles just as they want to have seen the fashionable film of the moment. But I think we are still at the outset of a new form of artistic expression, and that not only the texts but also the light accompaniment and the sound may become altered and improved in the years that lie ahead.

Thus, those who witnessed the first version at Avignon in 1954 will doubtless find fresh pleasure in seeing the 1956 or 1958 versions. The cinema has already accustomed us to similar revivals and the sound and light techniques which are in process of development enable high hopes to be placed in the future of sound-accompanied illuminations.

Certain reefs must nevertheless be avoided if these pageants are not to become vulgar, while the hold which this new art has on the public is developed. I must apologise for having to quote once more Martin Demezil(7), but in my view he sums up admirably the conditions for success in the following few lines: "A sound and light pageant must, to be of any value, constitute a 'poem,' which is not made up of a determined number of syllables and assonances, but of elements from the spheres of architecture and nature, and from the historic past. To adapt more or less felicitously a score and lighting effects to a dramatic text, while endeavouring to associate them with the building used as the scenery, is, I think, the opposite and to be avoided. After all, it is the historic building itself that is the spirit to be exalted and revived. Then, provided that the author and the composer of the score leave their own individuality out of it; provided that the producer keeps a tight hold on the invisible bonds that release the magic; that the technicians have found the countless solutions expected of them; that all are imbued with the team spirit, composed of frank exchanges of opinion which some of us have the joy of knowing; provided that the team is not hampered in its work by jacks-in-office who so readily make their voices heard, and provided finally that a spirit of grace has presided over the undertaking, the 'poem' can come to life, anonymously and collectively, being made up of the fusion of its craftsmen in that great and mysterious voice where colour and sound gives answer."

Nevertheless, at the present moment the most varied interests are already deriving benefit from these pageants. In spite of the very high cost of electrical installations and production, every undertaking soon pays its way and often, as in the case of Chambord and Versailles, from the beginning of the second year. It is laid down by the department of historical buildings that the profit must be used for maintaining

the works of art themselves. This has already made it possible to carry out certain repair work, which otherwise the Fine Arts department could not have done in time to avoid serious damage owing to the scanty budget allowed it by the State.

As regards the development of tourism in the regions where these pageants are organised, this is very considerable. The results I have mentioned do not take into account the sums spent by visitors in hotels, restaurants, etc., in the region. Even static illuminations create a certain attraction in a town, and the tourist staying there likes to make his way in the evening to those lighthouses which are the illuminated buildings. This has been realised by certain towns, Dijon for instance where, since the year when the A.F.E. meeting was held there, the principal buildings are floodlit each evening during the season. Moreover, the public lighting installations have been brought up to date and the traders, following the example of the city fathers, have increased the lighting of their shop windows and keep it on until late at night.

Thus the floodlighting of old buildings benefits all concerned including the makers of lamps and apparatus, and not forgetting the electricity undertaking which thus finds a wonderful market for the night-time current of its hydro-electric stations.

## Conclusion

By floodlighting these lovely works of art which our forefathers created with love and often with faith, we breathe new life into them and set them once more before the eyes of our contemporaries, who are amazed at the treasures enshrined in their past. May they then realise the value of this patrimony, not only by protecting it from the ravages of time, but also by preventing the frightful destruction looming before us through the ever more devastating inventions of atomic science which threaten to destroy mankind.

Light, which we serve with all our hearts, likewise benefits from discoveries, but from peaceful discoveries designed to improve the well-being of man in his work and in his leisure. I think that as lighting engineers we may derive some satisfaction from the fact that our work serves mainly the cause of peace without which there is no lasting joy on our planet.

## Acknowledgments

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# A Preliminary Study of Reflected Glare

By P. PETHERBRIDGE, B.Sc. (*Member*), and
R. G. HOPKINSON, B.Sc. (Eng.), Ph.D., M.I.E.E. (*Fellow*)

**Summary**

Bright light sources, reflected in glossy or semi-matt surfaces, can cause glare which may give rise to serious complaints. The best palliative is naturally to avoid the use of specularly reflecting surfaces, but in many situations this is quite impossible.

A study has therefore been initiated of the factors which give rise to reflected glare. This study, although in the preliminary stages, has already demonstrated the important fact that the chief manifestation of reflected glare is the *distraction* caused, rather than discomfort or disability.

## (1) Introduction

The form of glare which has received the greatest attention is that produced by light received directly on the eyes from the glare sources. There is, however, another way in which glare can be very commonly experienced and to which people react in a somewhat different manner. This is reflected glare.

There have been a number of publications on reflected glare, particularly in the American literature, but these have all dealt with the effect on visibility, and have not studied the discomfort and distraction effects which are in many circumstances of much the greater importance.

Examples of reflected glare are frequently met with when desk and bench tops are finished with a glossy surface. In such circumstances the careful design of the cut-off to light may be of no assistance as an insurance against seeing the reflected image of the bare lamp.

A typical example of reflected glare which was recently noticed in a Danish school is shown in Fig. 1. There the reflected images of two light fittings seen in the glossy Formica desk top immediately adjacent to the book were found to cause severe distraction when endeavouring to look at the book. It was noticed at the time, however, that the actual discomfort glare produced by the reflected images was very small. But no matter where one sat in the room, there were reflected images of one, two or more lamps in the desk top. The direct glare, on the other hand, was negligible, for louvred fittings had been used which completely shielded the lamps from a direct view when in the normal position sitting at the desks.

The different problems arising from reflected glare prompted the Building Research Station to give the matter somewhat closer attention, and a laboratory study has been initiated from which the preliminary results are now available. The aim is to simulate reflected glare in the laboratory under controlled and measurable conditions and then to study the relative degrees of discomfort and distraction produced by the reflected glare in comparison with the direct glare.

## (2) Experiments and Results

The basis of the method is to measure the luminance and the subtended solid angle of the reflected images at the observer's eye, and the luminance of the surroundings, including the desk top, and to deduce from the B.R.S. glare formula[1] what the glare discomfort would be expected to be for the average observer. Direct appraisals of the glare are also made by the observers, recognising, of course, that these appraisals may not necessarily be those of the average observer.

Initial tests with typical fittings employed in school classrooms and offices showed

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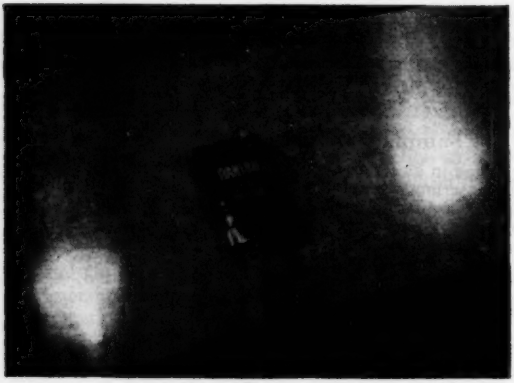

*Fig. 1. An example of reflected glare seen on a glossy desk top.*

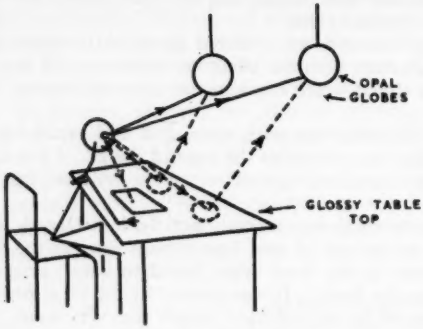


*Fig. 2. Diagram of reflected glare laboratory set-up and table of results.*

| Direction of view | Sensation | Glossy Black | Glossy White |
|---|---|---|---|
| ——→—— | Glare caused by sources | A | A |
| - - →- - - | Glare caused by reflections | C— | D— |
| - · - ➤- · - · | Distraction caused by reflections | Acute | Moderate |

A "Just intolerable" glare factor = 600
C— "Barely acceptable" ,, ,, = 50
D— "Barely perceptible" ,, ,, = 12

that the degree of glare discomfort caused by the reflected images was very small indeed. The reflected images could be viewed directly without discomfort, but if one looked at the work on the desk instead, there was a compelling distraction to turn the gaze back to the reflected image. Distraction was thus the more important effect.

The relative amount of reflected and of direct glare depends, of course, on the design of the fittings. A general lighting fitting will give a degree of direct glare discomfort considerably in excess of the discomfort due to the reflected image. A direct

lighting fitting with complete cut-off will, on the other hand, give little or no direct discomfort, but the same or perhaps more reflected glare than that from a general lighting fitting. Consequently the *relative* amount of reflected glare in such a direct lighting installation will be much greater, and so more noticeable.

In order that the glare produced by directly viewing the reflected images in the laboratory set-up could be made fairly severe, a mock-up installation of two specially-lamped opal globes was arranged (see Fig. 2). This enabled both the luminances of the glare sources and their apparent sizes when viewed directly and by reflection to be as large as possible.

Glossy table tops of two extremes of reflection factor (black and white) were studied, the results being shown in the table of Fig 2. Here it is seen that when the opal globes, which were on dimmers, were increased in luminance to a level at which they produced "just intolerable" discomfort (criterion A—glare factor 600[1]) by direct viewing, then when viewed by reflection they produced glare which was barely acceptable (criterion C minus—glare factor 50) in the glossy black table top, and glare which was barely perceptible (D minus—glare factor 12) in the glossy white table top.

In fact, in terms of the scale of glare criteria used for these studies, the reflections in the glossy black surface were about 2 steps less glaring than direct viewing of the globes, while the reflections in the glossy white surface were about 3 steps less glaring. (Three steps represents the whole difference between just intolerable and just perceptible.) In table tops of average reflection factor a difference of 2 to 2½ steps could be expected.

The degree of glare discomfort produced by the reflected images when looking at the visual task was even less than that recorded when looking directly at the images, but this glare sensation was very difficult to distinguish from the dominating sensation of distraction caused by the bright patches of light immediately adjacent to the visual task. It is seen from the table that this distraction or irritation was rated as "acute" with the glossy black table top, and even with a white table top the distraction was still rated as "moderate."

## (3) Conclusion

This study confirmed that what is sometimes loosely referred to as "reflected glare" is actually, apart from the disability effect, a combination of a mild degree of the pain-discomfort associated with direct viewing of a glare source, together with a predominant sensation of distraction which causes a subjective feeling of irritation and dissatisfaction far in excess of the actual pain-discomfort present.

The work is part of the research programme of the Building Research Board, and this note is published by permission of the Director of Building Research.

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